

# Key to Unit 4-1 Provincial Practice Questions

## Part 1- Multiple Choice

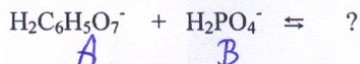
1 B	21 D	41 D	61 A
2 C	22 C	42 D	62 D
3 C	23 B	43 A	63 A
4 C	24 C	44 E	64 C
5 A	25 C	45 B	65 A
6 A	26 C	46 D	66 D
7 D	27 D	47 A	67 D
8 B	28 C	48 A	68 D
9 B	29 D	49 D	69 D
10 C	30 B	50 C	70 D
11 D	31 B	51 D	71 C
12 D	32 B	52 C	72 C
13 C	33 B	53 A	73 C
14 D	34 A	54 D	74 D
15 D	35 C	55 B	75 B
16 D	36 A	56 D	76 A
17 D	37 D	57 B	77 B
18 B	38 C	58 D	78 C
19 A	39 D	59 A	
20 C	40 D	60 A	

## Chemistry 12 – Provincial Practice Questions

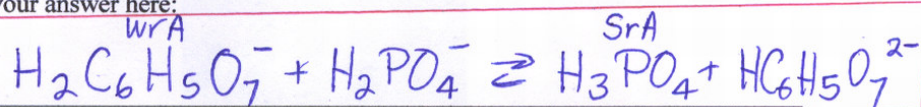
### Written Response Questions

# KEY

1. Consider the following amphiprotic anions reacting with each other:



- a) Complete the Bronsted-Lowry acid-base equilibrium for the predominant reaction. Write your answer here:



- b) Does the equilibrium above favour reactants or products? reactants
- c) Explain your answer to (b). *the weaker conjugate acid ( $\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$ ) is on the reactant side.*

2. Calculate the pH of a 2.5 M  $\text{C}_6\text{H}_5\text{OH}$  solution.

WA  $K_a = 1.3 \times 10^{-10}$

$$\text{C}_6\text{H}_5\text{OH} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{C}_6\text{H}_5\text{O}^-$$

[I]	2.5	<del> </del>	0	0
[C]	-x	<del> </del>	+x	+x
[E]	2.5-x	<del> </del>	x	x

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{C}_6\text{H}_5\text{O}^-]}{[\text{C}_6\text{H}_5\text{OH}]} = \frac{x^2}{(2.5-x)} \leftarrow \text{Assume } 2.5-x \approx 2.5$$

$$K_a \approx \frac{x^2}{2.5}$$

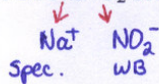
$$x^2 = 2.5 K_a$$

$$[\text{H}_3\text{O}^+] = x = \sqrt{2.5(1.3 \times 10^{-10})}$$

$$[\text{H}_3\text{O}^+] = 1.8028 \times 10^{-5} \text{ M}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+]$$

$$\text{pH} = 4.74$$

**KEY**3. Calculate the pH of a 0.60 M NaNO<sub>2</sub> solution.

$$K_b \text{ NO}_2^- = \frac{K_w}{K_a \text{ HNO}_2} = \frac{1.0 \times 10^{-14}}{4.6 \times 10^{-4}} = 2.17 \times 10^{-11}$$

$$\text{NO}_2^- + \text{H}_2\text{O} \rightleftharpoons \text{HNO}_2 + \text{OH}^-$$

[I]	0.60		0	0
[C]	-x		+x	+x
[E]	0.60-x		x	x

$$x^2 = 0.60 K_b$$

$$[\text{OH}^-] = x = \sqrt{0.60(2.17 \times 10^{-11})}$$

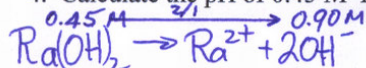
$$[\text{OH}^-] = 3.6116 \times 10^{-6} \text{ M}$$

$$\text{pOH} = 5.442$$

$$K_b = \frac{[\text{HNO}_2][\text{OH}^-]}{[\text{NO}_2^-]} = \frac{x^2}{(0.60-x)} \approx \frac{x^2}{0.60}$$

Assume  $0.60-x \approx 0.60$ 

$$\text{pH} = 8.56$$

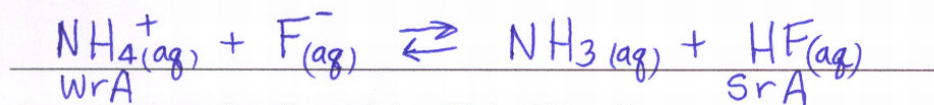
4. Calculate the pH of 0.45 M Ra(OH)<sub>2</sub>. (5B)

$$[\text{OH}^-] = 0.90 \text{ M}$$

$$\text{pOH} = 0.04576$$

$$\text{pH} = 13.95$$

5. Write the balanced formula equation to represent the complete neutralization reaction between aluminum hydroxide and sulphuric acid.

6. a) Write the net ionic equation for the acid-base reaction that occurs between KF<sub>(aq)</sub> and NH<sub>4</sub>NO<sub>3(aq)</sub>. (2 marks)

b) Are reactants or products favoured at equilibrium? (1 mark)

reactants are favoured.

7. A sample of pure KOH (s) is dissolved in water to make 8.0 L of solution and a pH = 9.82 results. Calculate the mass of pure KOH that was dissolved. (3 marks)

Plan: pH  $\rightarrow$  pOH  $\rightarrow$   $[\text{OH}^-]$  =  $[\text{KOH}]$   $\rightarrow$  mol KOH  $\rightarrow$  g KOH

$$\text{pH} = 9.82$$

$$\text{pOH} = 14.00 - 9.82$$

$$\text{pOH} = 4.18$$

$$[\text{OH}^-] = \text{antilog}(-4.18)$$

$$[\text{OH}^-] = 6.607 \times 10^{-5} \text{ M}$$

$$[\text{KOH}] = 6.607 \times 10^{-5} \text{ M}$$

$$\frac{\text{mol}}{\text{M/L}}$$

$$\text{mol KOH} = 6.607 \times 10^{-5} \text{ M} \times 8.0 \text{ L} = 5.2855 \times 10^{-4} \text{ mol}$$

$$\text{mass KOH} = 5.2855 \times 10^{-4} \text{ mol KOH} \times \frac{56.1 \text{ g}}{1 \text{ mol}} = 3.0 \times 10^{-2} \text{ g}$$

$$\begin{aligned} & 39.1 + 16.0 + 1.0 \\ & = 56.1 \end{aligned}$$

$$\text{mass KOH} = 3.0 \times 10^{-2} \text{ g or } 0.030 \text{ g}$$

8. At 20°C, the pOH of a sample of water is 7.085. Calculate the value of  $K_w$  for water at 20°C using this data.



In neutral water pH = pOH

$$\text{p}K_w = \text{pH} + \text{pOH}$$

$$\text{p}K_w = 2 \text{pOH} = 2(7.085)$$

$$\text{p}K_w = 14.17$$

$$K_w = \text{antilog}(-\text{p}K_w)$$

$$= \text{antilog}(-14.17)$$

$$K_w = 6.76 \times 10^{-15}$$

9. a) Which has a higher conductivity, 2.0 M  $\text{H}_2\text{S}$  or 0.01 M HBr?

0.01 M HBr

- b) Justify your answer using calculations.

Lower ion concentrations means lower conductivity

HBr is a SA so



so  $[\text{H}_3\text{O}^+]$  and  $[\text{Br}^-]$  are both 0.01 M

$\text{H}_2\text{S}$  is a weak acid



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{HS}^-]}{[\text{H}_2\text{S}]} = \frac{x^2}{2.0 - x}$$

2.0		0	0
-x		x	x
2.0-x		x	x

assume  $2.0 - x \approx 2.0$

$$K_a \approx \frac{x^2}{2.0} \quad x^2 = 2.0 K_a \rightarrow [\text{H}_3\text{O}^+] = x = \sqrt{2.0(9.1 \times 10^{-8})} = 4.3 \times 10^{-4} \text{ M}$$

10. At a particular temperature a 1.0 M HCN solution has a pH = 4.05. Calculate the value of  $K_a$  at this temperature. (4 marks)

$$pH = 4.05$$

$$[H_3O^+] = \text{antilog}(-4.05) = 8.9125 \times 10^{-5} M$$

$$HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$$

[I]	1.0		0	0
[C]	$-8.9125 \times 10^{-5}$		$+8.9125 \times 10^{-5}$	$+8.9125 \times 10^{-5}$
[E]	$1.0 - 8.9125 \times 10^{-5}$		$8.9125 \times 10^{-5}$	$8.9125 \times 10^{-5}$

$$K_a = \frac{[H_3O^+][CN^-]}{[HCN]} = \frac{(8.9125 \times 10^{-5})^2}{(1.0 - 8.9125 \times 10^{-5})} = 7.9 \times 10^{-9} = K_a$$

11. A 0.65 M solution of  $CN^-$  has a pH of 12.13 at a certain temperature. Calculate the  $K_b$  of  $CN^-$  at this temperature.

$$pH = 12.13 \quad pOH = 14.00 - 12.13 = 1.87$$

$$[OH^-] = \text{antilog}(-1.87) = 0.01349$$

$$CN^- + H_2O \rightleftharpoons HCN + OH^-$$

0.65		0	0
-0.01349		+0.01349	+0.01349
0.65 - 0.01349		0.01349	0.01349

$$K_b = \frac{[HCN][OH^-]}{[CN^-]}$$

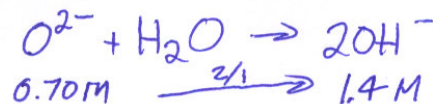
$$K_b = \frac{(0.01349)^2}{(0.65 - 0.01349)}$$

$$K_b = 2.9 \times 10^{-4}$$

12. Explain why  $H_3O^+$  is the strongest acid possible in aqueous solution.

All stronger acids (eg.  $HNO_3$ ,  $HCl$ ) ionize 100% in aqueous solution to produce  $H_3O^+$  ions (levelling effect)

13. What is the pH of a 0.70 M oxide solution?



$$[OH^-] = 1.4 M$$

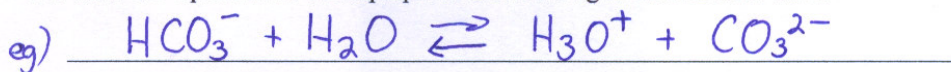
$$pOH = -\log(1.4)$$

$$= -0.146$$

$$pH = 14 - pOH$$

$$pH = 14.15$$

14. Write the equation for an amphiprotic anion acting as an acid with water.



15. How much water needs to be added to 500.0 mL of a solution of pH = 2.000 to bring the pH to 2.301.

initial soln. 

pH	$[\text{H}_3\text{O}^+]$
2.000	0.0100 M
2.301	0.00500 M

$$FV = \frac{IC \times IV}{FC} = \frac{0.0100 \times 500.0 \text{ mL}}{0.00500}$$

$$FV = 1000. \text{ mL}$$

Water Added =  $FV - IV$   
 $= 1000. \text{ mL} - 500.0 \text{ mL} = \boxed{500. \text{ mL}}$

16. A 0.60 M solution of a weak acid has a pH = 1.78. Use calculations and the table of acids to identify which acid it is.  $\text{pH} \rightarrow [\text{H}_3\text{O}^+] \xrightarrow{\text{ICE}} K_a$

$\text{pH} = 1.78 \quad [\text{H}_3\text{O}^+] = \text{antilog}(-1.78) = 0.016596 \text{ M}$

$\text{HA} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{A}^-$

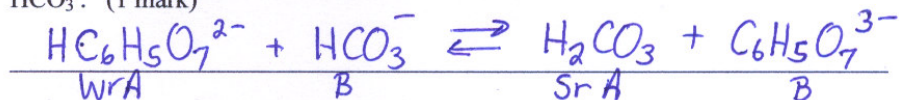
0.60	0	0
-0.016596	+0.016596	+0.016596
0.60 - 0.016596	0.016596	0.016596

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

$$K_a = \frac{(0.016596)^2}{(0.60 - 0.016596)} = 4.7 \times 10^{-4}$$

Close Match with  $\text{HNO}_2$  ( $K_a = 4.6 \times 10^{-4}$ )

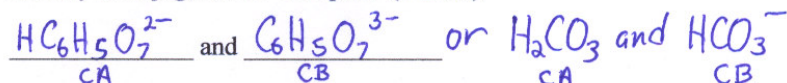
a) Write an equation to represent the predominant reaction when  $\text{HC}_6\text{H}_5\text{O}_7^{2-}$  is mixed with  $\text{HCO}_3^-$ . (1 mark)



b) Justify your statement by comparing  $K_a$  values. (1 mark)

$K_a \text{HC}_6\text{H}_5\text{O}_7^{2-} = 4.1 \times 10^{-7} > K_a \text{HCO}_3^- = 5.6 \times 10^{-11}$  so  $\text{HC}_6\text{H}_5\text{O}_7^{2-}$  acts as the acid reactant

c) Identify a conjugate acid-base pair. (1 mark)



d) Predict whether equilibrium will favour the production of reactants or products. Explain. (2 marks)

Prediction: The equilibrium in a) favours Reactants

Explanation:  $\text{HC}_6\text{H}_5\text{O}_7^{2-}$  (on the reactant side) is a weaker acid than  $\text{H}_2\text{CO}_3$  (on the product side). Equilibrium always favours the weaker acid.